Robt Patterson Esq
with kind regards of the author

THE METHOD AND AIM

OF

NATURAL HISTORY STUDIES

BEING AN INTRODUCTION TO

A COURSE OF LECTURES ON NATURAL HISTORY DELIVERED TO WORKING MEN IN THE EDINBURGH MUSEUM OF SCIENCE AND ART

By PROFESSOR ALLMAN, F.R.S., F.R.S.E., M.R.I.A.

PUBLISHED UNDER THE SANCTION OF THE DEPARTMENT OF SCIENCE AND ART.

EDINBURGH
EDMONSTON & DOUGLAS
1868.

EDINBURGH : PRINTED BY THOMAS CONSTABLE,

FOR

EDMONSTON AND DOUGLAS.

LONDON . . . . . HAMILTON, ADAMS, AND CO.

CAMBRIDGE . . . . . MACMILLAN AND CO.

DUBLIN . . . . . M'GLASHAN AND GILL.

GLASGOW . . . . . JAMES MACLEHOSE.

RB64144

THE METHOD AND AIM OF NATURAL HISTORY STUDIES.

In accepting the duties which have been imposed upon me, of delivering a course of lectures on Natural History to the working men of Edinburgh, I have been influenced by a conviction of the value of natural history studies to every one who regards the cultivation of his intellect, no matter in what section of the community his lot may have been thrown.

And yet it is not without misgivings that I have undertaken these duties—misgivings that their aim and purport may not be understood; for I am not going to talk to you of the construction and mode of working of machines; of the composition of dyes or the mode of action of mordants; of the processes employed in calico-printing, or silk weaving, or glass-blowing, or pottery. You must dismiss at once any idea that the natural history studies, in the somewhat limited sense in which we are about to consider them here, have, except in rare cases, any direct bearing, like those of the chemist or the physicist, upon the so-called practical pursuits of our times. And yet, for all that, I have sufficient confidence in your love of knowledge, sufficient faith in your desire for intellectual advancement, to make me believe that a simple exposition of some of the great truths with which the naturalist is conversant will not be thought lightly of by an assemblage of the intelligent working men of Scotland.

In the short course which I am about to deliver to you, I must employ the words Natural History in the restricted sense, which confines them to the history of the animal kingdom, or, as it is briefly called, Zoology. I propose, however, to devote

the present lecture to an exposition of the method which we must pursue in the study of living beings generally, if we would hope for any valuable results, as well as of the advantages to be derived from it as a source of intellectual strength and a source of intellectual pleasure. And, once for all, let me remind you that there is no such thing as a working man's natural history. In addressing you I shall, of course, endeavour to avoid all purely technical modes of expression which have not been sufficiently explained to you, for I have no right to speak to you in a language which you have had no opportunity of learning; but yet what I shall say to you I would say to all who would aim at the development of their intellectual and moral nature. I speak to you as members of the great community of thinking men, and appeal to those intelligent principles which are common to us all, whether we be workers with the hand or workers with the head—whether they guide the labours of the so-called working man, or inspire the thoughts of the poet, the historian, or the philosopher.

Natural History exerts itself primarily through the exercise and training of our observing faculties. There is no department of study in which these faculties are so constantly and so powerfully drawn into operation as in the studies of the naturalist. The naturalist is in the highest sense of the phrase the *observer of Nature*. He watches and records its facts and its phenomena. Nothing can be allowed to escape him; for a truth apparently the most unimportant may, when traced in all its bearings, have a significance far beyond what the inexperienced student would have dreamed of. Thus it is that by a systematic observation of the external world, the naturalist soon feels that he can take a broader and a surer grasp of this marvellous creation, and finds that avenues hitherto closed have become opened up to him, and that through them the mind receives new and unlooked-for materials of thought—materials given freely and without measure, and unspeakably rich.

But the simple observation of objects and phenomena constitute only the groundwork on which the science of Natural History is founded. The facts which have been thus determined by observation must be carefully compared. Their relations to one another, the relations of each organized being to every other

organized being, as well as to itself at different periods of its existence, its relations to the surrounding world and to past epochs of the world's history, must all engage the earnest attention of the naturalist; for it is from the study of these that the truths are educed out of which Natural History as a science can alone be developed.

These various modes of contemplating the facts with which simple observation has made us acquainted, give rise to the discovery of certain new classes of truths, which constitute so many special departments of Biology, or the science of living beings; and I shall now beg your attention to the place which each of them holds in the constitution of this science, illustrating my observations as far as possible by examples.

The basis of a philosophical knowledge of organized beings, or "organisms," as, for the sake of shortness, they are simply called, lies in *anatomy*, which renders us acquainted with the form, structure, and relative position of the parts of which the organized being is composed.

But the naturalist may also compare an organized body with itself at different periods of its existence. In this way he acquires a knowledge of the phenomena of *development*, and of the laws by which these phenomena are controlled. There thus arises a department of biology which is scarcely equalled by any in its attractiveness to the inquirer, and in the value of its results. By the study of development we become acquainted with the changes of the organism from the earliest moment when we have any evidence of its existence onwards through every varying phase of form until we find it reaching that ultimate state to which all its previous forms are but the steps of a graduated progress. Here it is that the most marvellous truths have revealed themselves, and here it is that recent researches have been rewarded with results which have been mainly instrumental in conferring on the natural history sciences that high position which they now occupy among the departments of philosophic thought.

An example will enable us to appreciate the value of the particular kind of truths which the study of animal development has made known to us.

It has now been positively ascertained, by the most careful

observations, that almost every animal, from man himself downwards, originates in an egg, and it is highly probable that when we obtain the means of still further extending our observations, it will be found that there is no exception to the absolute universality of this law.

As soon as the conditions necessary for development are present, the egg enters on a series of remarkable changes which have for their ultimate object the production of a living being similar to that with which the egg originated. The first set of changes which the egg undergoes in its development are in all essential points the same in every animal. They are very curious, but time will not allow me to do more than state to you their result, which is the production of a peculiar organized membrane which is formed on the surface of the yolk, and is named the "blastoderm," or "germinal membrane;" it is in this that the embryo originates, and from the moment that the germinal membrane has been completed, development changes, as it were, its course, and thenceforth goes on in a different direction for each great division of the animal kingdom.

Let us now turn our attention to development, as observed in the highest group of animals, that known as the mammalia, which includes man himself as one of its representatives, and let us note the changes which here immediately follow the formation of the germinal membrane. A definite circumscribed oval thickening becomes apparent on the germinal membrane, and in this thickening, which is known as the "embryonic spot," a narrow longitudinal groove makes its appearance. The sides of the groove next grow upwards in the form of two ridges, which becoming higher and higher, arch over the groove, and uniting with one another by their free edges, ultimately convert the groove into a closed tube.

In the tube thus formed the great centres of the nervous system, namely, the brain and spinal chord, originate. In the meantime the edges of the embryonic spot extend themselves downwards in a direction exactly opposed to that of the ridges just mentioned, and like them ultimately unite so as to form another tube parallel to and below that which has been formed for the nervous centres. In this second tube the blood-vascular and digestive systems are developed. The human being at th

early period of his development thus consists essentially of two parallel tubes quite separate from one another, one of which gives origin to the great centres of the nervous system, and the other to the blood-vascular and digestive systems.

It is not necessary for our present purpose to pursue the progress of development further than the point to which we have thus arrived, even had we time to do so, and I now only desire you to note, that the special value of the observations I have been describing lies in the fact that the particular plan of construction on which I have shown that the embryo is formed in the early stage of man's existence is common to him, and every other member of that great division of the animal kingdom which is known as the *vertebrata,* or those animals which possess a true brain and spinal chord protected by a skull and back-bone, or by some representative of these parts ; while no such type of construction can be found in any other division of the animal kingdom, each being formed on its own special plan, which completely excludes that of every other.

Now, we have in this a fact directly opposed to a speculation which only a few years ago had obtained very general acceptance among biologists both in this country and on the Continent, namely, that the higher animals in the course of their development passed through all the types of form which characterize the lower, and accordingly that man himself passed through every one of the great types which exist in the animal kingdom, possessing in his earliest embryonic stage the form of the lowest animal, and thence step by step passing through all the others, until he culminated in that which distinguishes the human being. To the test of a rigid observation such speculations must be subjected, and the careful study of the phenomena of development in the vertebrate embryo proves —as was shown by the great embryologist, Von Bär—that the progress is not from one type to another, but from a more general to a more special condition of one and the same type, —a fact which demolishes at once and for ever the theory of progression from type to type, and all the speculations which have been based upon it.

Another example taken from a very different group of the animal kingdom will tend still further to convince you of the

interest which attaches itself to the study of development. Many of you are doubtless acquainted with certain soft, clear, gelatinous creatures which are popularly known as sea-blubbers and jelly-fishes, and which frequent our sea-shores often in vast multitudes. They are active and beautiful creatures, bell-shaped, or formed somewhat like an umbrella, and it is by the alternate contraction and expansion of the bell, the shutting and opening, as it were, of the umbrella, that they propel themselves through the surrounding water. It is vain to think of preserving them, they are among the frailest and most perishable creatures of the sea; but the diagrams before you will serve to give an idea of their forms, and recall them to the memory of such of you as have already seen them.

You are possibly familiar too with certain plant-like productions which also occur in abundance in the sea around our shores. You will see them growing on the rocks at low-water, or entangled in the lines of the fishermen, or thrown in upon our coasts after a gale. Specimens of them are on the table before you, while the enlarged drawings on the wall will serve still farther to impress upon you their curious plant-like forms. By those whose attention has never been given to the study of Natural History, they would be regarded as true plants; and our Newhaven fishermen, recognising their plant-like shapes, and noticing in many the appearance of blossoms on their stems and branches, know them by the expressive name of "sea-flowers." In truth, they are rooted to the sea-bed as the flowers of our gardens are rooted to the soil, while their branches clothe themselves with blossoms which bud and expand beneath the water. They are blossoms however with the life of the animal, for they shrink when you touch them, and eat when you feed them. The entire organism is a strange colony of buds, and the blossoms are its mouths and its stomachs, which take in and swallow and digest the food which serves for the nutrition of the whole.

But what have these wonderful sea-flowers rooted to the rock to do with the active free-swimming jelly-fishes which swarm in our bays and estuaries, and people the surface of the sea hundreds of miles away from land? "Nothing," would have been the ready answer not very many years ago; but the study

of development has revealed new facts, and created new conceptions of the organic world. Let us see what it tells us of the jelly-fish and the sea-flower.

You will collect some of the smaller and simpler of these jelly-fishes, and place them uninjured in a glass of sea-water, where you can study their beautiful forms and graceful motions, and note the phenomena of their lives. They are male and female, and after a while the female will have laid her eggs. It is these eggs whose development you are now to watch. They will pass through the stages which, as I have already said, are common to the eggs of all animals, and which result in the formation of that blastoderm or germinal membrane of which I have spoken. But here terminates all resemblance to the plan of development with whose examination we have been just engaged, for instead of the formation of the two tubes by which the vertebrate embryo is characterized, we see that in our jelly-fish, the blastoderm, with the remains of the yolk which it encloses, has become elongated into an oval-shaped body, and that this develops over its surface microscopic hairs, called "cilia," which are kept in a state of constant vibration, and by lashing the surrounding water, carry the little embryo from place to place. At length the cilia disappear, the embryo fixes itself by one end, and never afterwards stirs from the spot to which it has thus become rooted. A mouth now becomes developed at the opposite end, and leads into a stomach which has been hollowed out within the body of the embryo. Round the mouth a circle of arms called tentacles, and intended for the capture of its prey, begin to grow and spread from a centre like the rays in the flower of a daisy. We can already see the form of the sea-flower foreshadowed in our embryo jelly-fish; there is its root and its stem, and the animated blossom on its summit, and now a bud is put forth from its side, and this bud grows into a branch, and develops another blossom on its summit; and then again, another bud, and another, and another is shot forth, and the simple solitary embryo is converted into a miniature tree with hundreds of branches, and covered with starry blossoms, every branch and every blossom having in itself an individual and independent life, and yet all united to one another by an organic bond, which confers upon the

assemblage an individuality of its own, and unites the whole into a marvellous colony, to which each contributes its labour, while each participates in the welfare of the community.

But the whole story has not yet been told, nor has the relation between the jelly-fish and the sea-flower been yet fully laid before you. While the sea-flower, which has thus sprung from the egg of the jelly-fish, has been putting forth bud after bud, and feeding through its hundred mouths, and growing and developing as a plant extends its branches and develops its flowers, it has produced nothing which can be compared to the seed of the plant or the egg of the animal, for it is neither male nor female, it is sexless and sterile. At length another kind of bud begins to shoot forth from it, and as this enlarges we see that it is something very different from any other bud that has yet sprung from the sea-flower. We soon begin, in fact, to recognise in the new bud the features of a jelly-fish, and at last the perfect form is attained, and the bud then breaks from its supporting stem, and with an energy unknown to the rooted sea-flower which bore it, it dashes away, a genuine jelly-fish, through the surrounding water; a jelly-fish, no longer sexless, like the sea-flower from which it sprung, but male or female, with an organization fitting it for the perpetuation of its race. When maturity is attained, the female deposits her eggs as we have already seen, and thus renews the marvellous cycle.

Having thus acquired a knowledge of the anatomy and of the development of an organism, we are in a condition to determine the true meaning of its parts and their exact significance in the plan of its construction; and then by comparing the parts of one organism with those of another, as well as by comparing with each other the several parts of the same organism, their true relations become apparent, and we begin to recognise in many cases a beautiful unity of composition which would otherwise have entirely escaped us. The peculiar relations known to biologists under the name of "Homology" thus show themselves, and their recognition is one of the most marked features in the present philosophic aspect of biological science.

By homology we mean a fundamental unity of plan between two parts of different kinds of organisms, or between two

different parts of the same organism, and the unity thus discovered is sometimes of the most startling and unexpected kind.

Let us take an example:—On comparing the respiratory organs of a dog with those of a cod-fish, we find that the dog breathes by means of lungs, while the breathing organs of the fish are its gills. Now beyond the simple identity of function of the lung and the gill there is nothing whatever in common between the two organs, and we are easily disposed to believe that the lung of the dog is totally unrepresented in the fish.

There exists, however, in the fish, as most of you know, an organ called the swimming-bladder, whose function, though not yet sufficiently understood, is generally regarded as that of enabling the fish to alter its specific gravity, and thus rise or sink at will in the water. It is a membranous sac, as you see from the preparations and model before you; and it is not likely that one of you would for a moment think of comparing it to the lung of an air-breathing quadruped.

It would be impossible in the present lecture to detail the observations and line of reasoning by which the true nature of the swimming-bladder of the fish has been ascertained, and I must therefore content myself with simply stating the result at which the philosophic naturalist has arrived. It is this: that the swimming-bladder of the fish is the exact representative of the lung of the quadruped, that it is fundamentally identical with it, though it may have lost in a great measure, or even entirely, its respiratory function, and have assumed an office of a very different import in the economy of the animal. The swimming-bladder of the fish is thus said to be homologous with the lung of the quadruped, which means that it is the same organ, notwithstanding its altered form and its different function.

Interesting and instructive illustrations might also be adduced, in which the relations of homology, instead of being between the parts of different animals, are between different parts of the same animal. Thus it can be shown that in the lobster, its stalked eyes, its horns or antennæ, its jaws, and the fin at the posterior extremity of its body, very different as all these seem to be from one another, are in reality nothing more than peculiarly modified feet. In other words, that its eyes homolo-

gically represent a pair of organs which a little farther back have become antennæ, a little farther still have become jaws, while towards the middle of the animal's body they have taken the form of legs for walking, and at its posterior extremity are modified so as to constitute a broad fin-like tail for swimming.

The limits of a single lecture will not allow of my entering into greater detail regarding these curious relations, and I wish you, in the next place, to note that, by further combining the results thus derived from the study of anatomy and development, the biologist is enabled to lay the basis of a philosophic *classification*, for it is only by the comparisons involved in such study that we become aware of the true resemblances and differences between organisms, and learn to appreciate the real value and significance of those resemblances and differences.

Classification thus stands forth as one of the most striking characteristics of natural history; and so essential and prominent a place does it take in the natural history sciences, as to have earned for these the designation of "the classificatory sciences." The importance of this feature, and its reflected force on other and very different departments of thought, have been recognised by some of our greatest thinkers, and no less an authority than Bentham has given it as his opinion, that were it not for Linnæus and Jussieu, and the other masters in natural history classification, that important department of jurisprudence known as codification, or the digesting and scientific arrangement of laws, could never have existed.

We have now seen, that before we can acquire an adequate knowledge of an organized being, we must have made ourselves acquainted with its anatomy, with its development, and with its classification, with everything, in fact, which concerns its form and the form of its organs, as distinct from the functions or duties performed by these organs. A knowledge of such functions, however, is of no less importance than a knowledge of the parts by which the functions are performed; and while the study of form gives rise to that department of biology which is known as *morphology*, the study of functions gives rise to another department, named *physiology*.

It is impossible for me to do more at present than thus

mention physiology as a department of biological research. It is one which gives a special charm to the studies of the biologist, for he derives from it that peculiar pleasure which the mind experiences in the contemplation of plan, of purpose, of the fitness of a definite structure to the performance of a definite function.

There is, however, another group of facts, which, though it possesses certain intimate relations both with morphology and physiology, must yet be regarded from an independent point of view. I refer to that which bears upon the *causes* of the present and past forms of organic nature,—causes to be, in great measure, traced to the relations of the organism to the conditions of existence which surround it. A wide field of inquiry is here opened up, and though the investigations which it involves are still in their infancy, they have already, in the hands of our distinguished countryman, Mr. Darwin, received philosophic treatment, and produced results of great value. But here again the limits of a lecture forbid my doing more than thus allude to this new but most hopeful department of biological inquiry.

Another point of view from which organized beings admit of contemplation, is in their relation to the world around us as manifested in their *geographical distribution*, or what is also known as their distribution in space. We know that the physical conditions of the surface of our globe, the distribution of land and water, of heat, light, and moisture, are infinitely varied; and it is this unequal distribution of the conditions of life that necessitates a definite geographical distribution of plants and animals—definite areas upon the earth's surface, within which certain living beings, or great classes of such beings, are more or less rigidly confined. Now, while some of these areas of distribution are wide, others are singularly narrow. Here is a beautiful butterfly called the *Pyrameis cardui*, and known to insect-collectors by the name of the "painted lady," which is found in almost every quarter of the globe, for it is not only abundant in the British Isles, but it occurs in the north of Sweden, in Central and Southern Europe, in Asia, New Holland, the Cape of Good Hope, and North and South America; while the extraordinary blind and colourless water-newt on the

table before you is found nowhere in the world but in the dark subterranean lakes of Carniola in Southern Austria. Again, the echidna and ornithorynchus, as well as almost the whole of the curious group of animals called marsupial, or those in which the female, like the kangaroo, carries her young ones in an abdominal pouch, are confined to New Holland and some of the neighbouring islands.

An interesting feature in geographical distribution is presented by the humming-birds; for while all these beautiful little creatures are absolutely confined to America, they have a singularly wide distribution in latitude. The centre of their area is equatorial America, where a tropical sun is flashed back from their plumage of emerald and sapphire and ruby, and yet there is now before you a specimen from Sitka on the Pacific Coast of Russian America, while south of the equator they extend their range as far as the desolate shores of Tierra del Fuego.

Let us take another example illustrative of the phenomena of geographical distribution. The bats of our own country are familiar to most of you,—small winged quadrupeds about the size of a mouse, living upon insects which they pursue during the night, hunting them down on the wing.

Now, under the tropics in the East and West Indies, the bats attain to a size in comparison with which our own bats sink into insignificance. There are before you examples of some of these gigantic bats from the East Indian Islands. The remarkable fact here is, that while the bats of the Eastern and Western tropical regions resemble one another in the great size to which many of them attain, they are for the most part totally different in their habits. The huge bats of the Eastern area live upon fruits, and confine their depredations to the gardens of the inhabitants, while those of the Western area are cruel and bloodthirsty; they are the vampires of the traveller, and though their history has been obscured by much that is fabulous, there can no longer be any doubt that they subsist upon the blood of living warm-blooded animals, and that whole districts of the regions they infest have had to be abandoned by the herdsman who would save the remnant of his cattle from the rapacity of the vampires.

From these two centres, the one inhabited by gigantic frugivorous, the other by gigantic blood-sucking bats, we trace the order gradually diminishing in size as it approaches the colder regions of the globe, until in our own latitudes it has dwindled into the little insect-eating mammal familiar to us as it flits about in the twilight of a summer evening; this is nearly its northern limit; it can be traced a little farther north, and then it entirely disappears.

But besides the distribution of plants and animals in *space*, there is still, as already said, another kind of distribution with which the biologist must make himself acquainted, if he would form an adequate conception of the organic world. This is the distribution of organized beings in *time*, or what is usually known as their *palæontological* or *geological distribution*. Its study teaches us that there were in former periods of the world's history, a peopling of the earth by plants and animals, a Flora and Fauna as it is technically called, totally different from anything which exist at the present day. It teaches us too that different Floras and Faunas succeeded to one another in the course of time, one dying out, to be entirely replaced by another.

Let us, in illustration of this, contrast the life of one of the early periods of the world's history with what we now witness around us. There was a time, not the oldest regarding which we have intelligible and consistent facts, but yet a period so long ago that the mind becomes bewildered in its attempts to comprehend the multitude of the years which have intervened between that distant epoch and our own.

The period to which I allude is known in the geological history of our earth as that of the Devonian or Old Red Sandstone, a period which has received graphic and eloquent exposition from a working man of Scotland, the gifted Hugh Miller.

During the whole of the Devonian period, and that period must have run through many a long age,—a period to be reckoned not by centuries, but by millenniums,—during the whole of the great Devonian epoch, so far as the evidence now before us will enable us to arrive at a conclusion, there were no mammals on the surface of the earth—no animal which brought forth its young alive and nourished them with milk.

Further, there was no bird among the living things of that day, and no true reptile. The day when the milk-giving mammal and the bird and the reptile were to inhabit the earth had not yet dawned upon the world. There were amphibia, however, animals like the frog and the water-newt, and there were fishes in great abundance and of extraordinary forms. Attend for a moment to some of the strange shapes presented by these denizens of the ancient seas. Here is one, the pterichthys or wing-fish, with a pair of pectoral spines developed into two great wing-like arms, while its body was invested in an armour of strong bony plates. Here is another, the cephalaspis, with its head covered by a broad shield of enamelled bone, which protects it as with a helmet; and there were hosts of others, all clothed with strong coats of jointed mail, whose hard and polished surface might have turned the point of tempered steel. And then when we seek for evidence of a bony jointed back-bone in these otherwise truly vertebrate animals, we seek in vain, and in its stead we find indications only of a state of things which characterizes the unborn embryo of a vertebrate animal of our own times; for in those Old Red Sandstone fishes the place of a true vertebral column was taken by a "noto-chord," the name given by the anatomist to a cylindrical cellular rod, which precedes the vertebral column in the embryo, and which is totally destitute of the joints or segments which are to characterize the future back-bone of the develop-ing animal. This truly embryonic condition is found, as a rare exception, to be persistent in a few fishes of our own time, but in these fishes of the Old Red Sandstone it was the constant and normal condition.

Time will not allow me to enter deeper into the life of that old epoch of the world's history, and I must now content my-self with simply stating that among the other departments of organized existence by which it was characterized, we have forms no less singular than are to be found among its fishes. They had all passed away, however, with the conditions which accompanied them; and long before the present state of things had arrived, they had given place to another Fauna and another Flora, each destined to pass away in its turn and be succeeded by another, until after many an extinction of old forms and

many a birth of new, the organized beings of our own days came to constitute the life of the world. And with them came a great power, not material only, but spiritual, for man had at last taken his place in the Fauna of the world, and an intelligence different from all former intelligences came with him into existence—an intelligence which can look back into the times that are gone and forward into those that are to come; which can accumulate the acquisitions of former generations, and hand them down for fresh accessions to generations yet unborn,—an intelligence which recognises in the world a moral law, a responsibility for the past which cannot be evaded, a hope in the future which cannot be shaken.

To man's history, and his relation to the succession of events which palæontology shows us to have taken place upon the globe, recent researches have largely contributed; and when interpreted by the light which Natural History is capable of shedding on them, the old lake villages of Switzerland, the caves and gravels of Southern and Central Europe, with their evidences of coeval man, and the peat-bogs and kitchen-middens of the North, have afforded information of great value regarding the aboriginal inhabitants of Europe.

I cannot now dwell upon the discoveries which within the last few years have been made in this most important department of scientific research; and a single illustration which I shall select from the kitchen-middens or shell-mounds is all that can be here adduced. These are particularly abundant in Denmark, where they were first studied; they consist of mounds lying near the sea-shore, and composed of the empty shells of oysters, cockles, mussels, periwinkles, and other shell-fish, usually mixed with the bones of various animals, and occasionally containing human implements made of bone or stone, and of very rude workmanship.

Those shell-mounds were until lately supposed to be a purely geological formation, and had been described as raised beaches, or lines of sea-shore elevated above their original level by the action of subterranean forces. They are now, however, known to be entirely of artificial origin, and to indicate the sites of ancient villages, of which they are the "middens," or refuse-heaps, which, during a long succession of years, had accumulated

in the neighbourhood of the dwellings. The shell-fish had served the old villagers for food, and such bones as had contained marrow are almost invariably broken longitudinally, with the evident object of getting at their contents. No trace of iron or of other metals has been found in the kitchen-middens, while further evidence of their great antiquity is afforded by the fact that in many cases shells which occur in them have since entirely disappeared from the neighbouring shores.

Such evidence as we possess regarding the physical characteristics of these aboriginal races is derived, not from the mounds themselves, for these contain no human remains, but from coeval or nearly coeval burial-places, and it would appear from the skulls there found that they were a round-headed race, and had perhaps a greater resemblance to the Laplanders than to any other group of mankind of the present day. They must have lived in the grossest barbarism, totally unacquainted with the metals, without any knowledge of agriculture, and with no domestic animal save the dog, while they subsisted on the produce of the neighbouring coast, and on such wild animals as their inefficient weapons might enable them to overcome, and whose flesh and marrow afforded the materials of their feasts.

In the north of Scotland we have some excellent examples of kitchen-middens, especially in Morayshire, along the southern shores of the Moray Firth, where these ancient refuse-heaps have been investigated by Lubbock and others.

It was only a few months ago that I had an opportunity of examining these Morayshire kitchen-middens, and I am now enabled to lay before you some of the materials of which they are composed, consisting, as you see, of shells, and of bones split open for their marrow. A recent railway cutting passes through the middle of one of the mounds, and as I stood there a train happened to dash past me, and all at once there came to my mind the achievements of modern science, and the great names which have inseparably linked themselves with its progress, and then my thoughts rushed back through the long vista of the past until they rested on the untutored aborigines of the spot whereon I stood, who collected the shell-fish of the neighbouring rocks, and hunted down the wild game of their forests, and left behind them no record of their existence, save the rude

flint implement and the mouldering shell-mound on the lonely shore.

Important and significant, however, as are the facts which such researches have brought to light regarding the early condition of our race, what we yet know of man is almost nothing when compared to what still remains unknown; for of all the marvels of which this wondrous universe is so full, and of which some gleams of knowledge are here and there permitted to us, the most marvellous, after the mystery of God Himself, is the great mystery of humanity.

I have thus endeavoured to lay before you the various aspects under which the organized creation must be contemplated by the philosophic inquirer; and if you have followed me in what I have been saying, you will have acquired a sufficiently adequate knowledge of the aim, scope, and method of the biological sciences.

In the last place, let me assure you, that in the study of Natural History, and in the knowledge which is the result of that study, you will find a source not only of intellectual power and of intellectual riches, but of real unalloyed pleasure. For there is another element in the external world besides that which appeals to the simple judgment of the philosopher; there is the element of the wonderful and of the beautiful, which responds no less completely to the imaginative faculty within us.

The beauty of the external world is a reality which we cannot ignore—it is a truth, and no less than the physical truths of the universe it claims from the philosophic mind a philosophic treatment. In all great truths there is an æsthetic or poetic element, and the more complete is our knowledge of the physical truths of the outer world, the more abundant will be the sources which minister to our longing after æsthetic truth, and the deeper and more lasting will be the pleasure we derive from them—a pleasure unknown to him who passes through life ignorant of the phenomena and laws which reveal themselves to the scientific student.

The subjects of the naturalist's studies are everywhere, and for materials on which to exercise our observing and reflective faculties we need not pass beyond the limits of our own land; for within the British Isles are all the conditions of a rich and

varied life which is ever present to the student, whether he seeks it in its inland haunts, or studies it upon the shores of the sea, that never-failing source of original observation, where discoveries, if he only looks for them, are sure to reward his labours. And then there are our glorious Highlands, with their breezy mountains and heathery moors, and deep sea-lochs through which the ocean itself flows into the very heart of the hills,—all have their own forms of life and their own forms of beauty, where the naturalist may study great truths and find the expression of wide-embracing laws. They have their own Fauna, from the wild creatures of the moor and of the mountain, bird and beast and insect, and living things of burn and of loch, to those strange dwellers in the sea, whose study has, within our own times, opened up new fields of thought. And they have their own Flora, that lovely Highland Flora, where the azalea and the dryas and the linnæa, the mountain saxifrage and campion and primula, recall the Flora of Alpine snows and of Arctic wastes —a simple vegetation, humble remnant, it may be, come down to us from those far-distant ages of the past, when the glacier scooped out its path over that grooved and fluted rock, and when those boulders, now scattered over the hill-side, fell upon the old sea-bed from the grasp of the iceberg.

If I have now said enough to make you see that there is something to love in the science whose exposition it is my duty to undertake, if I have succeeded in making you desire to know more of it than you do, I shall feel that neither you nor I have lost the time during which I have had the pleasure of addressing you,—I shall feel that the purpose of my lecture has been attained.

EDINBURGH : T. CONSTABLE,
PRINTER TO THE QUEEN, AND TO THE UNIVERSITY.